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(54) A HYDRAULICALLY CONTROLLED INTAKE/EXHAUST VALVE

HYDRAULISCH BETÄTIGTE ANSAUG/AUSLASS HUBVENTIL

SOUPAPE D'ADMISSION/ECHAPPEMENT A COMMANDE HYDRAULIQUE

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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates to a intake/exhaust valve assembly for an internal combustion engine.

2. DESCRIPTION OF RELATED ART

[0002] Internal combustion engines contain an intake valve and an exhaust valve for each cylinder of the engine. In a compression ignition (CI) engine the intake valve allows air to flow into the combustion chamber and the exhaust valve allows the combusted air/fuel mixture to flow out of the chamber. The timing of the valves must correspond to the motion of the piston and the injection of fuel into the chamber. Conventional CI engines incorporate cams to coordinate the timing of the valves with the piston and the fuel injector. Cams are subject to wear which may affect the timing of the valves. Additionally, cams are not amenable to variations in the valve timing during the operation of the engine.

[0003] U.S. Patent No. 5,125,370 issued to Kawamura; U.S. Patent No. 4,715,330 issued to Buchl and U.S. Patent No. 4,715,332 issued to Kreuter disclose intake valves that are controlled by solenoids. Each valve is moved between an open position and a closed position by energizing the solenoids. The amount of power required to actuate the solenoids and move the valves is relatively large. The additional power requirement reduces the energy efficiency of the engine.

[0004] WO-A- 92/07172, U.S. Patent Nos. 4,200,067 and 4,206,728 issued to Trenne; U.S. Patent Nos. 5,248,123, 5,022,358 and 4,899,700 issued to Richeson; U.S. Patent No. 4,791,895 issued to Tittizer; U.S. Patent No. 5,237,968 issued to Miller et al. and U.S. Patent No. 5,255,641 issued to Schechter all disclose hydraulically controlled intake valves. The hydraulic fluid is typically controlled by a solenoid control valve. The solenoid valves described and used in the prior art require a constant supply of power to maintain the valves in an actuating position. The continuous consumption of power reduces the energy efficiency of the engine. Additionally, the solenoid control valves of the prior art have been found to be relatively slow thus restricting the accuracy of the valve timing. It would therefore be desirable to provide a camless intake valve that was fast and energy efficient.

[0005] Some large diesel engines utilize a "Jake" brake technique for slowing down the vehicle when the engine is not providing fuel to the internal combustion chambers. A Jake brake maintains the intake and exhaust valves in the closed position during the compression stroke of the pistons. Near top dead center the exhaust valves are opened to release the air from the chamber so that the compressed air does not provide stored energy to return the piston to the bottom dead center position. The engine must thus work to continually compress the air within the internal combustion chambers. The additional work reduces the speed of the engine and the vehicle. Jake brakes typically include complex mechanisms that control the valves during the breaking process. It would be desirable to provide a simple valve assembly to Jake brake an engine.

[0006] The Applicant's WO-A-96/36795 (prior art according to Art. 54(3) EPC) discloses a valve assembly comprising hydraulically driven pins controlled by a position control valve for moving a valve to an open position or to a closed position ; this document does not disclose a position control valve having a neutral position wherein there is no fluid communication between any of the valve ports.

[0007] According to the present invention there is provided a valve assembly for an internal combustion engine as claimed in claim 1.

[0008] Also in accordance with the present invention there is provided an internal combustion engine, comprising:

a block that has an internal combustion chamber, an exhaust port and an intake port;
a valve housing that is attached to said block;
an intake valve that is coupled to said valve housing and which can move between an open position, a closed position, and an intermediate position to control a flow of air through said intake port;
an exhaust valve that is coupled to said valve housing and which can move between an open position, a closed position, and an intermediate position to control a flow of exhaust through said exhaust port;
a first intake pin that is in selective fluid communication with a fluid that moves said intake valve to the open position;
a first exhaust pin that is in selective fluid communication with the fluid to move said exhaust valve to the open position;
a three position intake control valve which controls the movement of said first intake pin, wherein said three position intake control valve includes a first position which allows the fluid to flow to said first intake pin, a second position which allows fluid to flow from said first intake pin, and a neutral position which does not allow fluid flow and maintains said intake valve in said intermediate position;
a three position exhaust control valve which controls the movement of said first exhaust pin, wherein said three position exhaust control valve includes a first position which allows the fluid to flow to said first exhaust pin, a second position which allows fluid to flow from said first exhaust pin, and a neutral position which does not allow fluid flow and maintains said exhaust valve in said intermediate position;
a second intake pin that is in fluid communication

with the fluid and which moves said intake valve to the closed position when said three position intake control valve is in the second position; and,
a second exhaust pin that is in fluid communication with the fluid and which moves said exhaust valve to the closed position when said three position exhaust control valve is in the second position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The objects and advantages of the present invention will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, wherein:

Figure 1 is a cross-sectional view of a valve assembly of the present invention;

Figure 2 is a cross sectional view of a three position control valve shown in a neutral position;

Figure 3 is a cross-sectional view of the three position control valve shown in a first position.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Referring to the drawings more particularly by reference numbers, Figure 1 shows a valve assembly 10 for an internal combustion engine. The engine includes a block 12 which has an internal combustion chamber 14, an intake port 16 and an exhaust port 18. A piston 20 moves within the combustion chamber 14. It being understood that an engine typically contains a plurality of combustion chambers and associated valves and pistons.

[0011] The flow of air through the intake port 16 is controlled by an intake valve 22 that can move between an open position and a closed position. The flow of exhaust through the exhaust port 18 is controlled by an exhaust valve 24 that can move between an open position and a closed position. The valves 22 and 24 can also move to any intermediate position between the fully closed and fully opened positions. The intermediate positions are also considered open positions.

[0012] Each valve 22 and 24 has a stem 26 that extends through a bore 28 of a valve housing 30 that is attached to the block 12. The stem 26 and bore 28 of the valve housing 30 may have a corresponding thread that rotates the valves each time a valve moves between the open and closed positions. Rotation of the valves reduces nonuniform wear on the valve seat. Alternatively, the assembly may include a cam or other means for rotating the valves when the valves move between the open and closed positions.

[0013] Each intake/exhaust valve 22 and 24 is coupled to a plurality of first pins 32 and a plurality of second pins 34 by a collar 36. The collars 36 may be attached to the valve stems 26 by clamps 38. The first pins 32 are located within a plurality of chambers 40 that contain a fluid. The second pins 34 are located within a plurality of chambers 42 that contain the fluid. The chambers 40 and 42 are defined by the valve housing 30 and a manifold housing 44. The fluid may be the fuel of the engine or a separate hydraulic fluid.

[0014] The flow of fluid into the chambers 40 and 42 is controlled by a number of three position control valves 46. The control valves 46 may include either a single four-way valve for each valve, or a pair of three-way valves for each valve. To open an intake/exhaust valve 22 or 24 the corresponding control valve 46 is switched to a first position to allow fluid to flow into the chambers 40 to push the first pins 32 and move the valve 22 or 24 to the open position. The intake/exhaust valves are closed by switching the control valve 46 to provide pressurized fluid to the second pins 34. The pin chambers 40 are vented to a drain port to allow fluid to flow out of the chambers 40.

[0015] Figure 2 shows a preferred embodiment of a three-way three-position control valve 46. The control valve 46 includes a housing 48 which has return port 50, a pair of cylinder ports 52, and a pair of supply ports 54. The return port 50 is typically connected to a drain line of the engine. The supply ports 54 are typically connected to a pressurized fluid line. The first cylinder port 52 may be connected to the first pin chamber 40 or the second pin chamber 42. A four-way valve would have an additional cylinder port that is connected to the other pin chamber.

[0016] The control valve 46 has a first solenoid 58 and a second solenoid 60 which move a spool 62 within the housing 48. The spool 62 has a number of grooves 64 which allow fluid communication between the various ports when the solenoids are actuated. The spool 62 is maintained in a neutral position by a pair of springs 66. In the neutral position the spool 62 does not allow fluid communication between any ports of the valve 46. Each spring 66 is captured by the housing 48 and a needle assembly 68.

[0017] As shown in Figure 3, when the first solenoid 58 is actuated the spool 62 is moved to a first position. In the first position, the cylinder ports 52 are in fluid communication with the supply port 54. When the second solenoid 60 is actuated the spool 62 is moved a second position. In the second position the cylinder ports 52 are in fluid communication with the supply port 54.

[0018] The spool 62 and housing 48 are preferably constructed from a material which has an hystersis that maintains the position of the spool 62 even when power to the solenoids is terminated. The material is preferably a 52100 or 440C steel. The magnetic steel material allows the spool to be latched into the first or second position by providing a digital pulse to the solenoids. The spool 62 can be returned to the neutral position by providing a short pulse on the opposite solenoid, or providing a voltage of opposite polarity to the solenoid adja-

cent to the latched spool 62 to detach the spol 62 from the housing 48. The detached spool 62 is biased into the neutral position by the springs 66. Alternatively, digital pulses may be provided to both solenoids to iteratively move the spool 62 to the neutral position. The control valve 46 may have a position sensor 70, such as a hall sensor to sense the position of the spool 62. The solenoids 58 and 60 are typically connected to a controller 72 that provides the digital pulses to the control valve 46.

[0019] In operation, to open an intake/exhaust valve 22 or 24, the controller 72 switches the corresponding control valve(s) 46 to the first position to allow fluid to flow into the first pin chambers 40 and push the first pins 32. The fluid within the second pin chambers 42 is allowed to flow into the drain line of the engine.

[0020] The first pin chambers 40 may contain booster springs 74 to provide an additional force to open the intake/exhaust valves. The springs 74 also dampen the movement of the valve back to the closed position to prevent striking and corresponding wear on the valve seat.

[0021] The position of the valve 22 or 24 can be maintained by switching the control valve 46 to the neutral position and preventing fluid flow within the pin chambers 40 and 42. By providing a neutral position, the time interval that the intake/exhaust valve is opened can be varied for different operating conditions of the engine. By way of example, the valve position can be varied to change the amount of air drawn into the combustion chamber and released from the chamber during a Jake brake cycle.

[0022] The intake/exhaust valve can then be closed by switching the control valve 46 to pressurize the chambers 42 and push the second pins 34. The assembly 10 may include return springs 76 that bias the valves to the closed position.

[0023] While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art.

Claims

1. A valve assembly (10) for an internal combustion engine, comprising:

   a valve (22) movable between an open position and a closed position;
   a first hydraulically driven pin (32) operable to move said valve (22) to the open position;
   a second hydraulically driven pin (34) operable to move said valve (22) to the closed position; and,
   a position control valve (46) having a return port (50), a supply port (54), a first cylinder port (52) coupled to said first hydraulically driven pin (32), and a second cylinder port (52) coupled to said second hydraulically driven pin (34), said position control valve (46) operable to be in one of a first position wherein said first cylinder port (52) is in fluid communication with said supply port (54) and said second cylinder port (52) is in fluid communication with said return port (50), a second position wherein said first cylinder port (52) is in fluid communication with said return port (50) and said second cylinder port (52) is in fluid communication with supply port (54), and a neutral position wherein there is no fluid communication between any of said return port (50), said supply port (54), said first cylinder port (52), and said second cylinder port (52).

2. The valve assembly (10) as recited in claim 1, wherein said position control valve (46) includes a spool (62) that is located within a housing (48) and biased towards the neutral position by a pair of springs (66), said position control valve (46) further including a first solenoid (58) operable to pull said spool (62) to the first position and a second solenoid (60) operable to pull said spool (62) to the second position.

3. The valve assembly (10) as recited in claim 2, wherein said first and second solenoids (58, 60) are actuated by a digital pulse.

4. The valve assembly (10) as recited in claim 1, further comprising a booster spring (74) that is coupled to said first pin (32) to bias said valve (22) to the open position.

5. The valve assembly (10) as recited in claim 1, wherein said position control valve (46) consists of two three-way valves.

6. The valve assembly (10) as recited in claim 1, wherein said control valve (46) is a four-way valve.

7. The valve assembly (10) as recited in claim 6, further comprising a collar (36) that couples said first pin (32) and said second pin (34) to said valve (22).

8. An internal combustion engine, comprising:

   a block (12) that has an internal combustion chamber (14), an exhaust port (18) and an intake port (16);
   a valve housing (48) that is attached to said block (12);

an intake valve (22) that is coupled to said valve housing (48) and which can move between an open position, a closed position, and an intermediate position to control a flow of air through said intake port (16);
an exhaust valve (24) that is coupled to said valve housing (48) and which can move between an open position, a closed position, and an intermediate position to control a flow of exhaust through said exhaust port (18);
a first intake pin (32) that is in selective fluid communication with a fluid that moves said intake valve (22) to the open position;
a first exhaust pin that is in selective fluid communication with the fluid to move said exhaust valve (24) to the open position;
a three position intake control valve (46) which controls the movement of said first intake pin (32), wherein said three position intake control valve (46) includes a first position which allows the fluid to flow to said first intake pin (32), a second position which allows fluid to flow from said first intake pin (32), and a neutral position which does not allow fluid flow and maintains said intake valve (22) in said intermediate position;
a three position exhaust control valve (46) which controls the movement of said first exhaust pin, wherein said three position exhaust control valve (46) includes a first position which allows the fluid to flow to said first exhaust pin, a second position which allows fluid to flow from said first exhaust pin, and a neutral position which does not allow fluid flow and maintains said exhaust valve (24) in said intermediate position;
a second intake pin that is in fluid communication with the fluid and which moves said intake valve (22) to the closed position when said three position intake control valve (46) is in the second position; and,
a second exhaust pin that is in fluid communication with the fluid and which moves said exhaust valve (24) to the closed position when said three position exhaust control valve (46) is in the second position.

9. The engine as recited in claim 8, wherein said three position intake and exhaust control valves (46) each include a spool (62) that is located within a housing (48) and maintained in the neutral position by a pair of springs (66), said three position intake and exhaust control valves (46) further including a first solenoid (58) operable to pull said spool (62) to the first position and a second solenoid (60) operable to pull said spool (62) to the second position.

10. The engine as recited in claim 9, wherein said first and second solenoids (60, 62) are actuated by a digital pulse.

11. The engine as recited in claim 8, wherein said three position intake and exhaust control valves (46) consist of two three-way valves.

12. The engine as recited in claim 8, further comprising a pair of booster springs (74) that are coupled to said first intake and exhaust pins (32) to bias said intake valve (22) and said exhaust valve (24) to the open positions.

13. The engine as recited in claim 8, further comprising a pair of collars (36) that couple said first and second intake and exhaust pins (32, 34) to said intake and exhaust valves (22, 24).

Revendications

1. Ensemble de soupapes (10) pour un moteur à combustion interne, comprenant

une soupape (22) pouvant se déplacer entre une position ouverte et une position fermée ;
une première broche (32) à entraînement hydraulique utilisable pour déplacer ladite soupape (22) vers la position ouverte ;
une deuxième broche (34) à entraînement hydraulique utilisable pour déplacer ladite soupape (22) vers la position fermée ;
une soupape de commande de position (46) ayant un orifice de retour (50), un orifice d'alimentation (54), un premier orifice de cylindre (52) couplé à ladite première broche (32) à entraînement hydraulique, et un deuxième orifice de cylindre (52) couplé à ladite deuxième broche (34) à entraînement hydraulique, ladite soupape de commande de position (46) étant utilisable pour être dans une position parmi une première position dans laquelle ledit premier orifice de cylindre (52) est en communication fluide avec ledit orifice d'alimentation (54) et ledit deuxième orifice de cylindre (52) est en communication fluide avec ledit orifice de retour (50), une deuxième position dans laquelle ledit premier orifice de cylindre (52) est en communication fluide avec ledit orifice de retour (50) et ledit deuxième orifice de cylindre (52) est en communication fluide avec ledit orifice d'alimentation (54), et une position neutre dans laquelle il n'y a pas de communication fluide entre l'un quelconque dudit orifice de retour (50), dudit orifice d'alimentation (54), dudit premier orifice de cylindre (52) et dudit deuxième orifice de cylindre (52).

2. Ensemble de soupapes (10) selon la revendication 1, où ladite soupape de commande de position (46) comprend une bobine (62) qui est située à l'intérieur d'un logement (48) et pressée vers la position neutre par une paire de ressorts (66), ladite soupape de commande de position (46) comprenant en outre un premier solénoïde (58) utilisable pour tirer ladite bobine (62) vers la première position et un deuxième solénoïde (60) utilisable pour tirer ladite bobine (62) vers la deuxième position.

3. Ensemble de soupapes (10) selon la revendication 2, où lesdits premier et deuxième solénoïdes (58, 60) sont actionnés par une impulsion numérique.

4. Ensemble de soupapes (10) selon la revendication 1, comprenant également un ressort amplificateur (74) qui est couplé à ladite première broche (32) pour pousser ladite soupape (22) vers la position ouverte.

5. Ensemble de soupapes (10) selon la revendication 1, où ladite soupape de commande de position (46) est constituée de deux vannes à trois voies.

6. Ensemble de soupapes (10) selon la revendication 1, où ladite soupape de commande (46) est une vanne à quatre voies.

7. Ensemble de soupapes (10) selon la revendication 6, comprenant également un collier (36) qui couple ladite première broche (32) et ladite deuxième broche (34) à ladite soupape (22).

8. Moteur à combustion interne, comprenant :

un bloc (12) qui a une chambre de combustion interne (14), un orifice d'échappement (18) et un orifice d'admission (16) ;
un compartiment de soupapes (48) qui est attaché audit bloc (12) ;
une soupape d'admission (22) qui est couplée audit compartiment de soupapes (48) et qui peut se déplacer entre une position ouverte, une position fermée et une position intermédiaire pour commander un flux d'air à travers ledit orifice d'admission (16) ;
une soupape d'échappement (24) qui est couplée audit compartiment de soupapes (48) et qui peut se déplacer entre une position ouverte, un position fermée et une position intermédiaire pour commander un flux d'échappement à travers ledit orifice d'échappement (18) ;
une première broche d'admission (32) qui est en communication fluide sélective avec un fluide qui déplace ladite soupape d'admission (22) vers la position ouverte ;
une première broche d'échappement qui est en communication fluide sélective avec un fluide pour déplacer ladite soupape d'échappement (24) vers la position ouverte ;
une soupape de commande d'admission à trois positions (46) qui commande le mouvement de ladite première broche d'admission (32), où ladite soupape de commande d'admission à trois positions (46) comprend une première position qui permet au fluide de s'écouler vers ladite première broche d'admission (32), une deuxième position qui permet au fluide de s'écouler à partir de ladite première broche d'admission (32), et une position neutre qui ne permet pas au fluide de s'écouler et maintient ladite soupape d'admission (22) dans ladite position intermédiaire ;
une soupape de commande d'échappement à trois positions (46) qui commande le mouvement de ladite première broche d'échappement, où ladite soupape de commande d'échappement à trois positions (46) comprend une première position qui permet au fluide de s'écouler vers ladite première broche d'échappement, une deuxième position qui permet au fluide de s'écouler à partir de ladite première broche d'échappement, et une position neutre qui ne permet pas au fluide de s'écouler et maintient ladite soupape d'échappement (24) dans ladite position intermédiaire ;
une deuxième broche d'admission qui est en communication fluide avec le fluide et qui déplace ladite soupape d'admission (22) vers la position fermée quand ladite soupape de commande d'admission à trois positions (46) est dans la deuxième position ; et
une deuxième broche d'échappement qui est en communication fluide avec le fluide et qui déplace ladite soupape d'échappement (24) vers la position fermée quand ladite soupape de commande d'échappement à trois positions (46) est dans la deuxième position.

9. Moteur selon la revendication 8, où lesdites soupapes de commande d'admission et d'échappement à trois positions (46) comprennent chacune une bobine (62) qui est située à l'intérieur d'un logement (48) et est maintenue dans la position neutre par une paire de ressorts (66), lesdites soupapes de commande d'admission et d'échappement à trois positions (46) comprenant également un premier solénoïde (58) utilisable pour tirer ladite bobine (62) vers la première position et un deuxième solénoïde (60) utilisable pour tirer ladite bobine (62) vers la deuxième position.

10. Moteur selon la revendication 9, où lesdits premier et deuxième solénoïdes (60, 62) sont actionnés par une impulsion numérique.

11. Moteur selon la revendication 8, où lesdites soupapes de commande d'admission et d'échappement à trois positions (46) sont constituées de deux vannes à trois voies.

12. Moteur selon la revendication 8, comprenant également une paire de ressorts amplificateurs (74) qui sont couplés auxdites premières broches d'admission et d'échappement (32) pour pousser ladite soupape d'admission (22) et ladite soupape d'échappement (24) vers les positions ouvertes.

13. Moteur selon la revendication 8, comprenant également une paire de colliers (36) qui couplent lesdites première et deuxième broches d'admission et d'échappement (32, 34) auxdites soupapes d'admission et d'échappement (22, 24).

Patentansprüche

1. Ventilanordnung (10) für einen Verbrennungsmotor, umfassend ein Ventil (22), das zwischen einer geöffneten und einer geschlossenen Stellung bewegbar ist;

   einen ersten hydraulisch bewegten Stift (32), verwendbar, um das Ventil (22) in die geöffnete Stellung zu bewegen;
   einen zweiten hydraulisch bewegten Stift (34), verwendbar, um das Ventil (22) in die geschlossene Stellung zu bewegen; und
   ein Steuerventil (46) mit einer Auslassöffnung (50), einer Einlassöffnung (54), einem ersten Zylinderanschluss (52), der mit dem ersten hydraulisch bewegen Stift (32) verbunden ist, und einem zweiten Zylinderanschluss (52), der mit dem zweiten hydraulisch bewegten Stift verbunden ist, so betreibbar, dass sich das Steuerventil (46) sich in einer ersten Stellung, in der der erste Zylinderanschluss (52) eine Fluidverbindung zur Einlassöffnung (54) und der zweite Zylinderanschluss (52) eine Fluidverbindung zur Auslassöffnung (50) besitzt, in einer zweiten Stellung, in der der erste Zylinderanschluss (52) eine Fluidverbindung zur Auslassöffnung (50) und der zweite Zylinderanschluss (52) eine Fluidverbindung zur Einlassöffnung (54) besitzt oder in einer neutralen Stellung, in der keine Fluidverbindung zwischen der Auslassöffnung (50), der Einlassöffnung (54), dem ersten Zylinderanschluss (52) oder dem zweiten Zylinderanschluss (52) besteht, befinden kann.

2. Ventilanordnung (10) nach Anspruch 1, wobei das Steuerventil (46) umfasst:

   einen Steuerkolben (62) in einem Gehäuse (48), der durch ein Paar von Federn (66) in der neutralen Stellung als Ruhelage gehalten wird,
   eine erste Spule (58), um den Steuerkolben (62) in die erste Stellung zu ziehen, und
   eine zweite Spule (60), um den Kolben (62) in die zweite Stellung zu ziehen.

3. Ventilanordnung (10) nach Anspruch 2, wobei die erste und zweite Spule (58, 60) durch einen digitalen Puls eingeschaltet werden.

4. Ventilanordnung (10) nach Anspruch 1, weiterhin umfassend eine Triebfeder (74), die mit dem ersten Stift (32) verbunden ist und das Ventil (22) in der geöffneten Stellung vorspannt.

5. Ventilanordnung (10) nach Anspruch 1, wobei das Steuerventil (46) aus zwei Dreiwegeventilen besteht.

6. Ventilanordnung (10) nach Anspruch 1, wobei das Steuerventil (46) ein Vierwegeventil ist.

7. Ventilanordnung (10) nach Anspruch 6, weiterhin umfassend einen Kragen (36), der den ersten Stift (32) und den zweiten Stift (34) mit dem Ventil (22) verbindet.

8. Verbrennungsmotor, umfassend

   einen Block (12), der eine Verbrennungskammer (14), eine Auslassöffnung (18) und eine Einlassöffnung (16) enthält;
   ein Ventilgehäuse (48), das am Block (12) angebracht ist;
   ein Einlassventil (22), das mit dem Ventilgehäuse (48) verbunden ist und sich zwischen einer geöffneten Stellung, einer geschlossenen Stellung und einer mittleren Stellung bewegen kann, um einen Luftstrom durch die Einlassöffnung (16) zu regeln;
   ein Auslassventil (24), das mit dem Ventilgehäuse (48) verbunden ist und sich zwischen einer geöffneten Stellung, einer geschlossenen Stellung und einer mittleren Stellung bewegen kann, um einen Abgasstrom durch die Auslassöffnung (18) zu regeln;
   einen ersten Einlassventilstift (32), der sich in Kontakt mit einem Fluid befindet, die das Einlassventil (22) in die geöffnete Stellung bewegt;
   einen ersten Auslassventilstift, der sich in Kontakt mit einer Flüssigkeit befindet, die das Auslassventil (22) in die geöffnete Stellung bewegt;
   ein Einlasssteuerventil (46) mit drei Stellungen, das die Bewegung des ersten Einlassventilstifts (32) steuert, wobei in der ersten Stellung des Einlasssteuerventils (46) die Flüssigkeit zum ersten Einlassventilstift (32) hin fließt, in

der zweiten Stellung die Flüssigkeit vom ersten Einlassventilstift (32) weg fließt, und in einer neutralen Stellung die Flüssigkeit nicht fließt, wodurch das Einlassventil (22) in der mittleren Stellung gehalten wird;
ein Auslasssteuerventil (46) mit drei Stellungen, das die Bewegung des ersten Auslassventilstifts steuert, wobei in der ersten Stellung des Einlasssteuerventils (46) die Flüssigkeit zum ersten Auslassventilstift hin fließt, in der zweiten Stellung die Flüssigkeit vom ersten Auslassventilstift weg fließt, und in einer neutralen Stellung die Flüssigkeit nicht fließt, wodurch das Auslassventil (24) in der mittleren Stellung gehalten wird; einen zweiten Einlassventilstift, der sich in Kontakt mit der Flüssigkeit befindet und das Einlassventil (22) in die geschlossene Stellung bewegt, wenn sich das Steuerventil (46) in der zweiten Stellung befindet; einen zweiten Auslassventilstift, der sich in Kontakt mit der Flüssigkeit befindet und das Auslassventil (24) in die geschlossene Stellung bewegt, wenn sich das Steuerventil (46) in der zweiten Stellung befindet.

9. Verbrennungsmotor nach Anspruch 8, wobei die Einlass- und Auslasssteuerventile (46) mit drei Stellungen, jeweils einen Steuerkolben (62) in einem Gehäuse (48), die durch ein Paar Federn (66) in der neutralen Stellung gehalten wird;

eine erste Spule (58), um den Steuerkolben (62) in die erste Stellung zu ziehen; und
eine zweite Spule (60), um den Steuerkolben (62) in die zweite Stellung zu ziehen, umfassen.

10. Verbrennungsmotor nach Anspruch 9, wobei die erste und zweite Spule (60, 62) durch einen digitalen Puls eingeschaltet werden.

11. Verbrennungsmotor nach Anspruch 8, wobei die Einlass- und Auslasssteuerventile jeweils aus zwei Dreiwegeventilen bestehen.

12. Verbrennungsmotor nach Anspruch 8, weiterhin umfassend ein Paar von Treibfedern (74), die mit den ersten Einlass- und Auslassventilstiften (32) verbunden sind und das Einlassventil (22) und das Auslassventil (24) jeweils in der offenen Stellung vorspannen.

13. Verbrennungsmotor nach Anspruch 8, weiterhin umfassend ein Paar Kragen (36), die die ersten und zweiten Einlass- und Auslassventilstifte (32, 34) mit dem Einlass- bzw. Auslassventil verbinden.

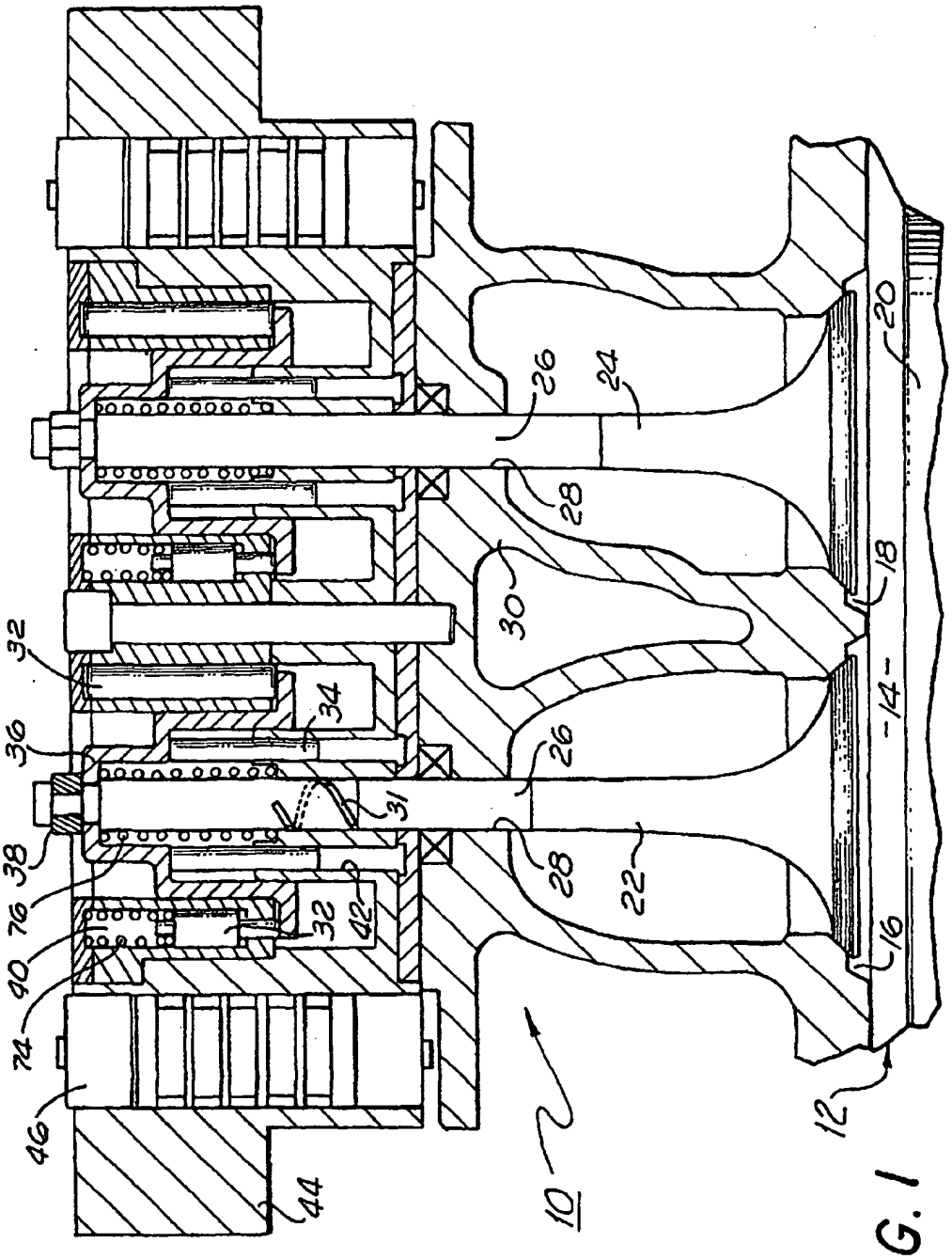
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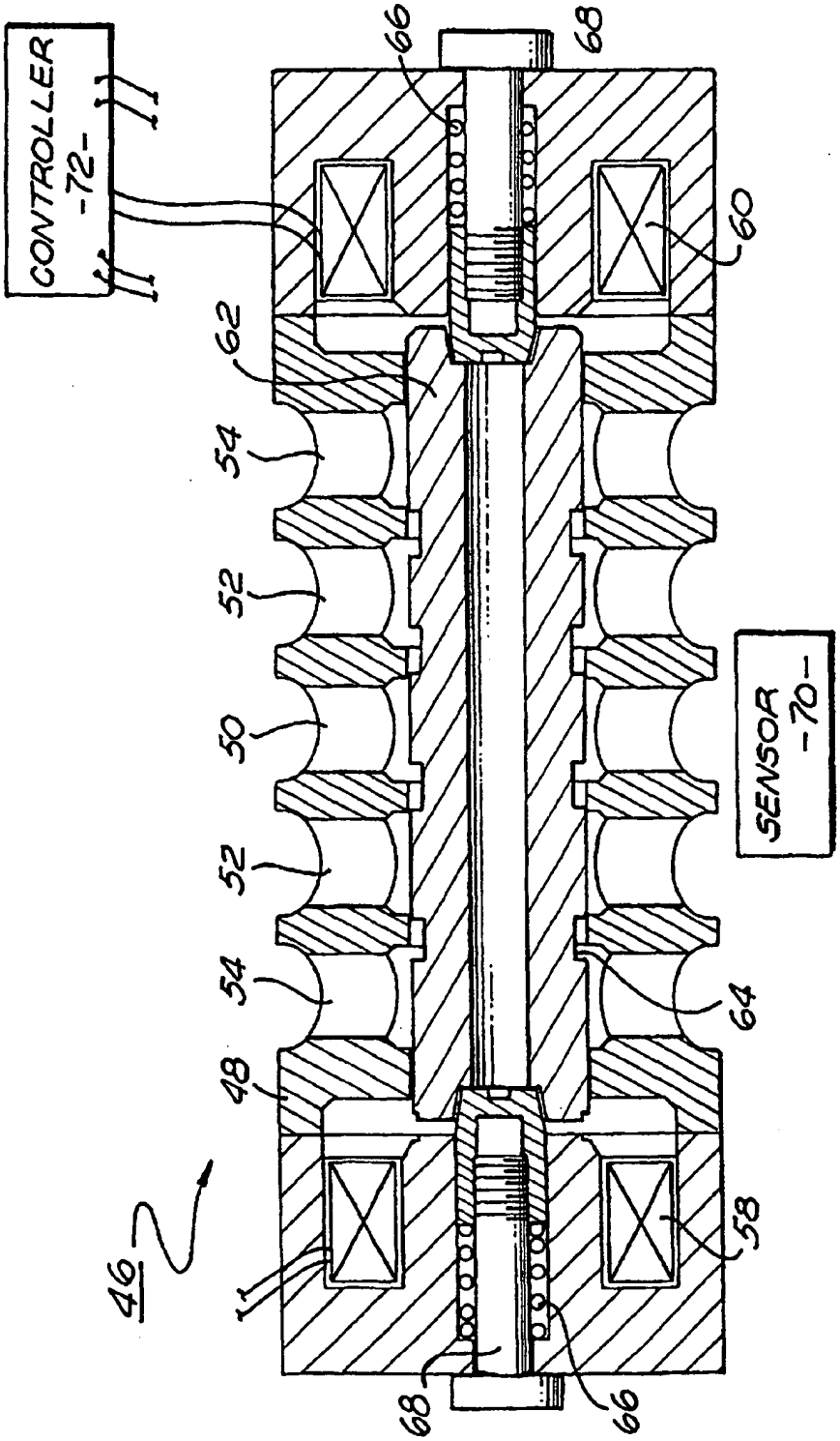
FIG. 1


CONTROLLER
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SENSOR
-70-

FIG. 2

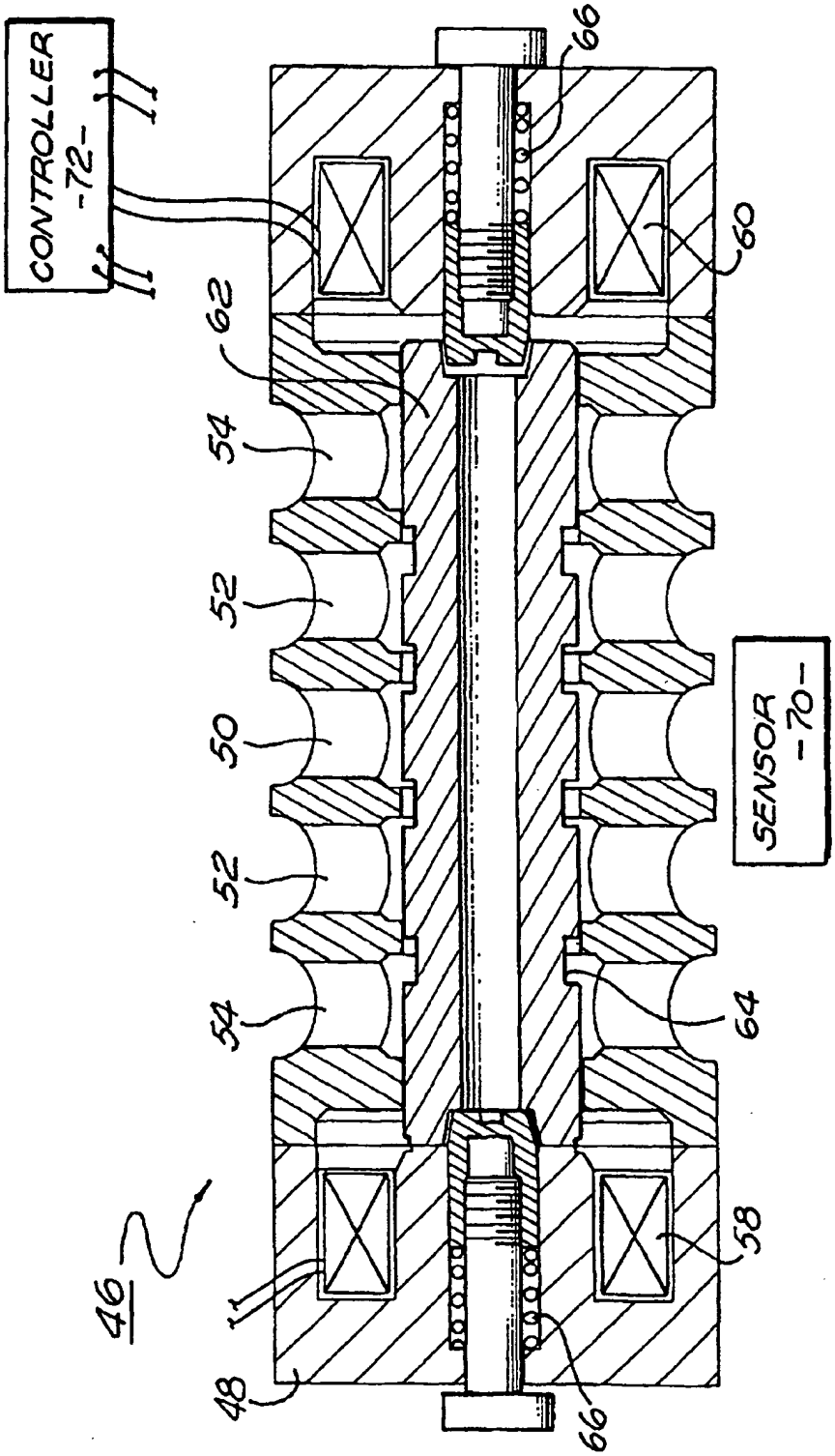

FIG. 3